Preview question

What’s “common” about the Common Criteria?
A. Every kind of product is evaluated against the same “protection profile.”
B. Anyone can perform the certification, without special government approval.
C. The certification applies to devices used in everyday civilian life, rather than in government or the military.
D. A single certification is recognized by the governments of many countries.
E. A single certification can be used for products from different vendors.

Outline

Capability-based access control (cont'd)
Side and covert channel basics
Announcements intermission
Transient execution covert channels
OS trust and assurance

(Object) capabilities

A capability both designates a resource and provides authority to access it
Similar to an object reference
Unforgeable, but can copy and distribute
Typically still managed by the kernel

Capability slogans (Miller et al.)

No designation without authority
Dynamic subject creation
Subject-aggregated authority management
No ambient authority
Composability of authorities
Access-controlled delegation
Dynamic resource creation

Partial example: Unix FDs

Authority to access a specific file
Managed by kernel on behalf of process
Can be passed between processes
Though rare other than parent to child
Unix not designed to use pervasively

Distinguish: password capabilities

Bit pattern itself is the capability
No centralized management
Modern example: authorization using cryptographic certificates

Revocation with capabilities

Use indirection: give real capability via a pair of middlemen
A → B via A → F → R → B
Retain capability to tell R to drop capability to B
Depends on composability
Confinement with capabilities
- A cannot pass a capability to B if it cannot communicate with A at all.
- Disconnected parts of the capability graph cannot be reconnected.
- Depends on controlled delegation and data/capability distinction.

OKL4 and seL4
- Commercial and research microkernels.
- Recent versions of OKL4 use capability design from seL4.
- Used as a hypervisor, e.g., underneath paravirtualized Linux.
- Shipped on over 1 billion cell phones.

Joe-E and Caja
- Dialects of Java and JavaScript (resp.) using capabilities for confined execution.
- E.g., of JavaScript in an advertisement.
- Note reliance on Java and JavaScript type safety.

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More confidentiality problems
- Careful access control prevents secret data from "leaking" through normal OS-mediated communication channels.
- Residual problem: channels not designed for communication.
- A major theme of ongoing computer security research.

Side channel vs. covert channel
- Side channel: information leaks from an unsuspecting victim.
- Covert channel: information intentionally leaked by an adversarial sender.
- Violating an isolation property.
- Sender and receiver work together.
- Distinction sometimes unclear or not observed.

Kinds of channels
- Software channels: undesired feature of program behaviors.
- Physical channels: channels mediated by the real world.
- Hardware channels: undesired feature of hardware behaviors.

Classic software covert channels
- Storage channel: writable shared state.
- E.g., screen brightness on a mobile phone.
- Timing channel: speed or ordering of events.
- E.g., deliberately consume CPU time.
Remote timing and traffic analysis

- Timing of events can also leak over the network
  - Classic example: time taken to process encrypted data
- Encrypted network traffic still reveals information via pattern and timing of packets
  - Classic example: keystrokes over SSH
  - Modern: “website fingerprinting” against HTTPS and Tor

Examples of physical side channels

- EM emissions and diffuse reflections from CRTs
- Power usage of computers and smart cards
- Smartphone accelerometer picks up speaker vibrations

Common hardware channel: cache timing

- Memory cache shared by processes and sometimes cores
- Cache state depends on pattern of previous accesses
- Cache hit or miss affects code execution speed

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Multiple BCMTA vulnerabilities found!

- Format string vulnerability in logging
- Race condition on file ownership check
- Instruction whitelist was too permissive

Midterm exam next Monday

- Usual class time and location
- Covers up through today’s lecture material
- Mix of short-answer and exercise-like questions
- Open books/notes/printouts, no computers or other electronics
- Sample exams (2013-2019) posted, solutions Wednesday

Exercise set 2

- Due Wednesday evening
- Join pre-created groups in Canvas
- Remember to cite any outside sources you used
- May not be graded before midterm, so ask questions early

Reversing the stack

```c
void func(char *str) {
    char buf[128];
    strcpy(buf, str);
    do_something();
    return;
}
```
### Payment app

```c
void payment(char *name, double amount_jpy, char *purpose, int purpose_len) {
    double amount_usd = amount_jpy / 109.23;
    char memo[32];
    strcpy(memo, "Payment for: ");
    memcpy(memo + strlen(memo), purpose, purpose_len);
    write_check(name, amount_usd, memo);
}
```

### Reverse range

```c
void reverse_range(int *a, int from, int to) {
    unsigned int *p = &a[from];
    unsigned int *q = &a[to];
    while (!(p == q + 1 || p == q + 2)) {
        *p += *q;
        *q = *p - *q;
        *p = *p - *q;
        p++; q--;
    }
}
```

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### Trusted and trustworthy

- Part of your system is trusted if its failure can break your security
- Thus, OS is almost always trusted
- Real question: is it trustworthy?
- Distinction not universally observed: trusted boot, Trusted Solaris, etc.

### Minimizing trust

- Kernel → microkernel → nanokernel
- Reference monitor concept
- TCB size: measured relative to a policy goal
- Reference monitor ⊆ TCB
  - But hard to build monitor for all goals

### How to gain assurance

- Use for a long time
- Testing
- Code / design review
- Third-party certification
- Formal methods / proof

### Trusted (I/O) path

- How do you know you’re talking to the right software?
- And no one is sniffing the data?
- Example: Trojan login screen
  - Or worse: unlock screensaver with root password
  - Origin of "Press Ctrl-Alt-Del to log in"
Evaluation / certification

- Testing and review performed by an independent party
- Goal: separate incentives, separate accountability
- Compare with financial auditing
- Watch out for: form over substance, misplaced incentives

Orange book OS evaluation

- Trusted Computer System Evaluation Criteria
- D. Minimal protection
- C. Discretionary protection
  - C2 adds, e.g., secure audit over C1
- B. Mandatory protection
  - B1 < B2 < B3: stricter classic MLS
- A. Verified protection

Common Criteria

- International standard and agreement for IT security certification
- Certification against a protection profile, and evaluation assurance level EAL 1-7
- Evaluation performed by non-government labs
- Up to EAL 4 automatically cross-recognized

Common Criteria, Anderson’s view

- Many profiles don’t specify the right things
- OSes evaluated only in unrealistic environments
  - E.g., unpatched Windows XP with no network attacks
- "Corruption, Manipulation, and Inertia"
  - Pernicious innovation: evaluation paid for by vendor
  - Labs beholden to national security apparatus

Formal methods and proof

- Can math come to the rescue?
- Checking design vs. implementation
- Automation possible only with other tradeoffs
  - E.g., bounded size model
- Starting to become possible: machine-checked proof

Proof and complexity

- Formal proof is only feasible for programs that are small and elegant
- If you honestly care about assurance, you want your TCB small and elegant anyway
- Should provability further guide design?

Some hopeful proof results

- seL4 microkernel (SOSP’09 and ongoing)
  - 75 kL C, 200 kL proof, 160 bugs fixed, 25 person years
- CompCert C-subset compiler (PLDI’06 and ongoing)
- RockSalt SFI verifier (PLDI’12)